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HARDMAN III: A Patriot Growth Application

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13. ABSTRACT (Maximum 200 words)

With assistance from the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Fort Bliss Field Unit, the Directorate of Combat Developments (DCD), U.S. Army Air Defense Artillery School at Fort Bliss, Texas, is evaluating HARDMAN III. DCD and ARI at Fort Bliss have applied the HARDMAN III methodology to a proposed improvement (Navigation Emplacement System) to the Patriot Air Defense System. HARDMAN III analyses included system performance requirements and projected manpower and personnel characteristics for Patriot MOS in the fielding years; also included were workload analyses and analyses of the effects of personnel quality and training and environmental stressors on mission performance. The Patriot Growth Application is a good example of the concept, methodology, and output of HARDMAN III analyses through user participation on an actual system. This research note is in a modular communication (briefing) format.

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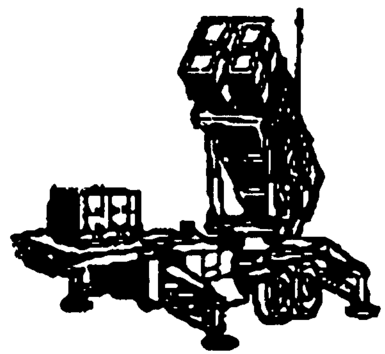
The Patriot Growth Application was used to demonstrate the capabilities of HARDMAN III and to provide potential users with a "hands-on" opportunity to evaluate it. This research note is the result of cooperation of the Materiel and Logistics Systems Division (MLSD) at the Directorate of Combat Developments, U.S. Army Air Defense Artillery School, Fort Bliss, Texas, and the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). Thanks to Lieutenant Colonel John Mania, MLSD Division Chief, Mr. Dan Silva, Deputy, and Major Womack, High to Medium Air Defense (HIMAD) Branch Chief, for allowing their personnel to participate in the evaluation. Special appreciation is extended to HARDMAN III evaluation participants Gerald Kinder, operations research and systems analyst, Captain Steve Perry, HIMAD weapons officer, and Kay Castillo, logistics management specialist. Recognition is also due to the many subject matter experts in the HIMAD Branch, the Organization and Personnel Systems Division, the Patriot Training Division, and the Patriot Training Development Division.

I would like to express my appreciation to those who gave me special assistance: Jonathan Kaplan, Charles Holman, and John Miles of the Manned Systems Group of ARI; Sue Dahl of Micro Analysis and Design; and Tom Bravo and Rich Adkins of Dynamics Research Corporation. Thanks go to Major Mark Levitt for gathering the necessary data input, to Craig Caldwell for the research note graphics, and to William Sanders for suggestions in the formal peer review process. Warm thanks are extended to Richard Christ and Michael Strub for their helpful comments on drafts of the research note and their support throughout the project.

HARDMAN III

PATRIOT GROWTH APPLICATION



Army Research Institute
Fort Bliss Field Unit
&
Materiel and Logistics Systems Division
Directorate of Combat Developments
U.S. Army Air Defense Artillery School
Fort Bliss, Texas

HARDMAN III: OVERALL PURPOSE

HARDMAN III is the product of a major developmental effort of the U.S. Army Research Institute (ARI) for the Behavioral and Social Sciences in Alexandria, Virginia. The overall purpose of HARDMAN III is to improve the design and acquisition process for hardware and software systems. HARDMAN III achieves this improvement by helping the user to determine realistic system performance criteria through mission simulation and to influence system design through an examination of the manpower, personnel, and training constraints likely to be present in the fielding years. HARDMAN III also aids in the evaluation of system designs in terms of the manpower and personnel characteristics needed to achieve system performance requirements.

HARDMAN III consists of a number of linked, software-based aids designed for ease of use. The aids can be used independently of each other or used in an integrative approach. System performance models can be built from scratch, modified, or "cut and pasted" across systems existing in the HARDMAN III data libraries. The software interface is "user friendly." The user does not need to write programs or algorithms and primarily selects from menu options. There is an extensive on-line help feature as well. The output is automatically organized into readable reports and the user simply requests the printout. HARDMAN III requires an IBM AT or equivalent computer with a minimum of 20M bytes of storage, 640K bytes of RAM, an enhanced graphics display, and DOS 3.0 or higher.

HARDMAN III

OVERALL PURPOSE:

- To assist the combat developer to determine realistic system performance criteria and to influence system design by examining the manpower, personnel and training constraints likely to be present in the fielding years.

- To assist in the evaluation of system designs in terms of the manpower and personnel characteristics needed to achieve system performance requirements.

HARDMAN III USER DEMONSTRATION

The U.S. Army Training and Doctrine Command (TRADOC) has agreed to participate in the test and evaluation of HARDMAN III. Fort Bliss was selected as a test site. The purpose of the user demonstration is to provide TRADOC users a "hands on" opportunity to evaluate HARDMAN III through its application to MANPRINT and system issues and to provide feedback to ARI for future HARDMAN III improvements.

HARDMAN III analyses were applied to an Air Defense system at Fort Bliss, Texas, in February, 1991. This demonstration was coordinated by the ARI Fort Bliss Field Unit and included user participation from the Materiel and Logistics Systems Division (MLSD) at the Directorate of Combat Developments (DCD), U.S. Army Air Defense Artillery School at Fort Bliss.

HARDMAN III
USER DEMONSTRATION

OBJECTIVES:

- To demonstrate the concept, methodology, and output of HARDMAN III analyses through user participation.
- To provide a forum for the evaluation of the potential utility of HARDMAN III to DCD.

PATRIOT MISSILE AIR DEFENSE SYSTEM

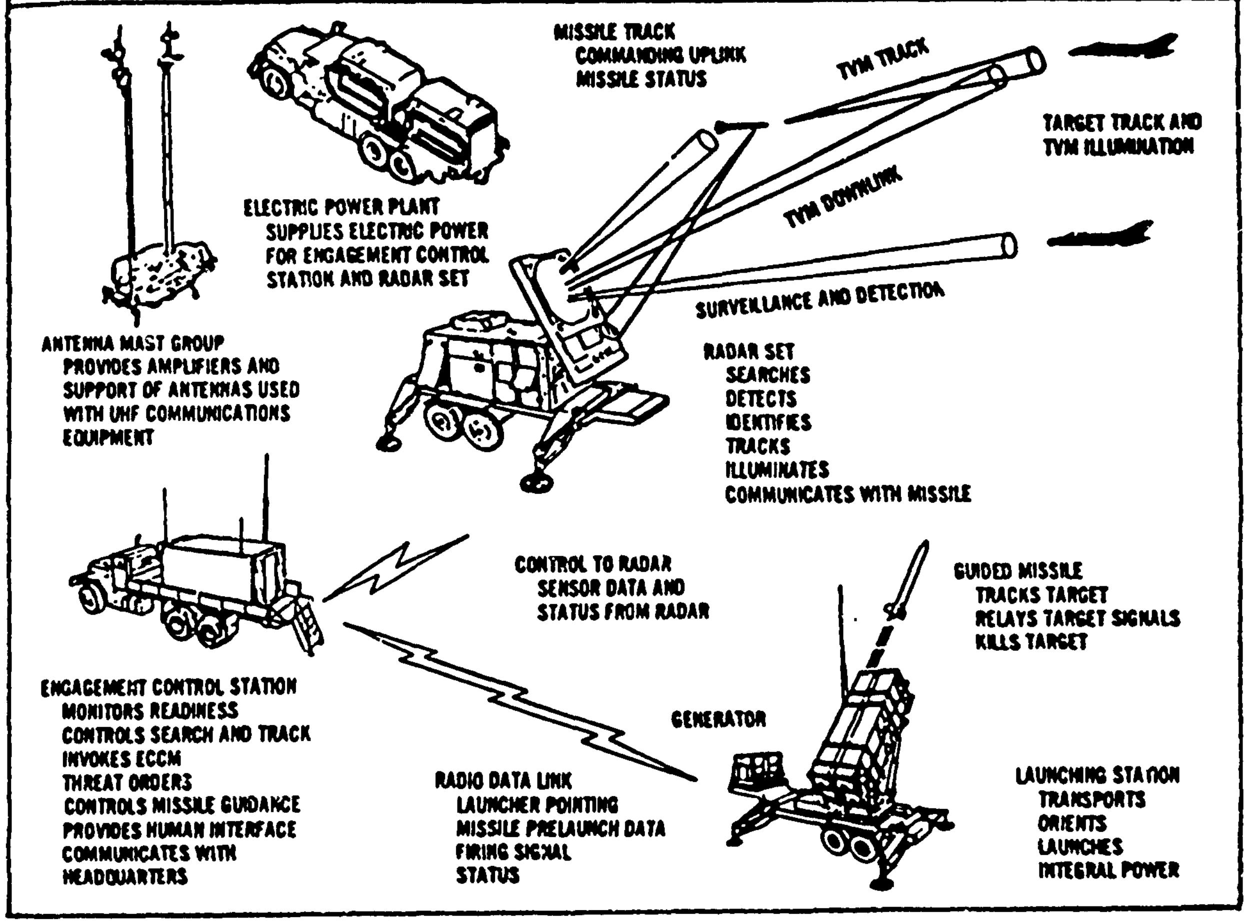
The Patriot Missile system is the centerpiece of theater air defense with its fast reaction capability, high firepower, and ability to operate in a severe electronic countermeasure environment. Patriot functions against targets within the very low to very high altitude boundaries to protect ground forces and high value assets. While Patriot fights as a battalion, its basic operational element is the firing battery. Normally there are six firing batteries in a Patriot Battalion.

The firing battery consists of an engagement control station (ECS), radar set (RS), electrical power plant (EPP), antenna mast group (AMG), and eight launching stations (LS). The system is highly automated combining high-speed digital processing with various software routines to effectively control the battlespace. The single radar, using phased array technology, provides for all tactical functions of airspace surveillance, target detection and track, and support of missile guidance.

SYSTEM OPERATION

The illustration below shows the scheme of operation of a Patriot fire unit and provides the principal functions of each major item of equipment.

PATRIOT FIRE UNIT OPERATIONS



HARDMAN III: PATRIOT GROWTH APPLICATION

The primary intent of the Patriot Growth program is to improve the system's capabilities to counter the postulated threat and address several deficiencies noted in the Mission Area Development Plan. The Materiel and Logistics Systems Division (MLSD), DCD at Fort Bliss is evaluating alternative Patriot Growth improvements to prioritize system development options. For the purpose of the HARDMAN III demonstration, analyses were limited to one Patriot Growth improvement in the operations arena (no maintenance aspects were considered).

The first step was to select which improvement to evaluate and then gather relevant documentation and necessary data input from subject matter experts (SMEs) to support the analyses. Execution of the various HARDMAN III software aids followed. The demonstration was concluded with synthesis of the results and a briefing on the HARDMAN III Patriot Growth Application to DCD and ARI personnel at Fort Bliss. This document records the briefing that was presented, with the objective of communicating the concept, methodology, and output of HARDMAN III analyses through user participation on an actual system.

PATRIOT GROWTH APPLICATION

APPROACH:

- Select Patriot growth improvement.
- Gather necessary data input.
- Conduct HARDMAN III analyses.
- Brief the concept, methodology, and output.

SELECTION OF PATRIOT GROWTH IMPROVEMENT

With input from the High to Medium Air Defense (HIMAD) Branch Chief and a Logistics Management Specialist from MLSD, the Navigation Emplacement System (NAVES) was selected as the improvement to undergo HARDMAN III analyses. NAVES is a combination of the Global Positioning System (GPS) receiver and a North Finding System (NFS). NAVES is proposed to improve Patriot Radar Set and Launching Station emplacement by: (1) providing the Patriot System with accurate axis position, attitude and azimuth data and (2) reducing the time to determine emplacement parameters by automating certain tasks now being performed manually. NAVES is proposed to require no additional vehicles, personnel, or Military Occupational Specialties (MOSs).

PATRIOT GROWTH IMPROVEMENT SELECTED

by
HIMAD Branch Chief and Logistics Management Specialist, MLSD, DCD and ARI-Bliss.

Navigation Emplacement System (NAVES)

- NAVES fulfills the Materiel Change Program (MCP) requirements of emplacement enhancement through accurate axis position, attitude, and azimuth data.
- NAVES will automate some emplacement tasks now being performed manually.
- NAVES is proposed to require no additional vehicles, personnel, or new military occupational specialities.

HARDMAN III ANALYSES

HARDMAN III analyses for the Patriot Growth application with NAVES were conducted by an Operations Research and Systems Analyst (ORSA) from MLSD and a research psychologist from ARI-Bliss. These analyses included the following HARDMAN III aids:

System Performance and RAM Criteria Aid (SPARC): The purpose of SPARC is to systematically describe system performance requirements through mission modeling and simulation. SPARC was used to evaluate the emplacement criteria for the Patriot system equipped with NAVES.

Manpower Constraints Aid (M-CON) and Personnel Constraints Aid (P-CON): The purpose of M-CON and P-CON is to give the combat developer manpower and personnel constraint information which impacts system design. M-CON and P-CON utilize a flow model to project manpower and personnel characteristics by MOS into the fielding year(s). Patriot MOSs for the analyses included 16T, 24T, and 31M.

Manpower-Based Systems Evaluation Aid (MAN-SEVAL): The purpose of MAN-SEVAL is to assist in the evaluation of whether a design is likely to meet system performance requirements with the crew sizes that will be available to operate and maintain the system once it is fielded. The Workload Analysis Aid (WAA) in MAN-SEVAL was used to examine task assignment and workload with the employment of NAVES.

Personnel-Based System Evaluation Aid (PER-SEVAL): The purpose of PER-SEVAL is to estimate, through mission simulation, how various factors (i.e., personnel characteristics, training frequency, environmental stressors) affect individual task and overall mission performance. This capability was demonstrated for the Patriot with NAVES application.

HARDMAN III ANALYSES

CONDUCTED BY ORSA,
from MLSD, DCD
and ARI

SPARC: SYSTEM PERFORMANCE REQUIREMENTS

M-CON & P-CON: PROJECTED POPULATION IN FIELDING YEARS

MAN-SEVAL: TASK ASSIGNMENT & WORKLOAD ANALYSES

PER-SEVAL: MISSION EFFECTIVENESS DUE TO PERSONNEL CHARACTERISTICS, TRAINING AND ENVIRONMENTAL FACTORS

NECESSARY DATA INPUT

The Patriot emplacement mission, already resident in the HARDMAN III data base, was used as a basis for discussion with Patriot subject matter experts (SMEs) in the HIMAD Branch, MLSD. SMEs modified these mission data to reflect employment of NAVES. The Patriot with NAVES emplacement mission formed the basis of the SPARC, MAN-SEVAL, and PER-PER-SEVAL analyses.

Information about future Patriot force structure changes, if any, and fielding plans for NAVES (e.g., fielding years and number of systems to receive NAVES) was gathered from SMEs in the Organization and Personnel Systems Division and the HIMAD Branch, MLSD. These data fed M-CON and P-CON analyses.

Crew position and task assignments for Patriot system emplacement were elicited from the Patriot Training Division, Patriot Department and the Patriot Training Development Division, Directorate of Training Development (DOTD). This information was needed for MAN-SEVAL and PER-SEVAL applications.

NECESSARY DATA INPUT:

- Started with baseline Patriot data base resident in HARDMAN III.
- Altered emplacement data to reflect NAVES for SPARC application.
  Source: HIMAD Branch, Materiel and Logistics Systems Division
- Force structure and fielding plans for M-CON & P-CON application.
  Source: Organization & Personnel Systems Division
  HIMAD Branch, Materiel and Logistics Systems Division
- Crew position and task assignments for MAN-SEVAL & PER-SEVAL application.
  Source: Patriot Training Division, Patriot Department
  Patriot Training Development Division, DOTD

SPARC: SYSTEM PERFORMANCE AND RAM CRITERIA AID

SPARC provides an aid for development of system performance requirements through mission simulation. Missions can be developed from scratch, modified, or "cut and pasted" across systems existing in the SPARC data library. Each mission is decomposed into functions and subfunctions, with the relationships among them defined. Each subfunction is defined in terms of performance standards (i.e., time and accuracy criteria) and performance estimates (e.g., mean, standard deviation).

Once the necessary model modifications have been made to reflect the new or improved system, mission simulations can be run. Executing a simulation is as simple as selecting the option from the menu and designating the number of mission iterations to run. The simulation model is based on the Micro Saint task network simulation tool. Mission simulations reflect variations in performance time and accuracy as are found in operational testing. The simulation predicts the performance attained for an overall mission, as well as for each function and subfunction. The analyst can compare these simulation results (time and accuracy achieved) to proposed performance criteria to determine whether the criteria or model need modifications.

SYSTEM PERFORMANCE AND RAM CRITERIA AID
(SPARC)

CONCEPT:

To assess system criteria and predict performance through mission simulation.

METHOD:

- Modelled missions are resident in the SPARC data library.
- Each mission is decomposed into functions and subfunctions.
- Each subfunction has performance standards (criteria) and performance estimates (e.g., mean and standard deviation).
- Modify existing missions to reflect a new system.
- Simulate missions (with N iterations).
- Simulation results show the performance attained for an overall mission, as well as for each function and subfunction.
- Compare simulation results to performance criteria to determine whether the criteria need modifications.

PATRIOT EMPLACEMENT MODEL

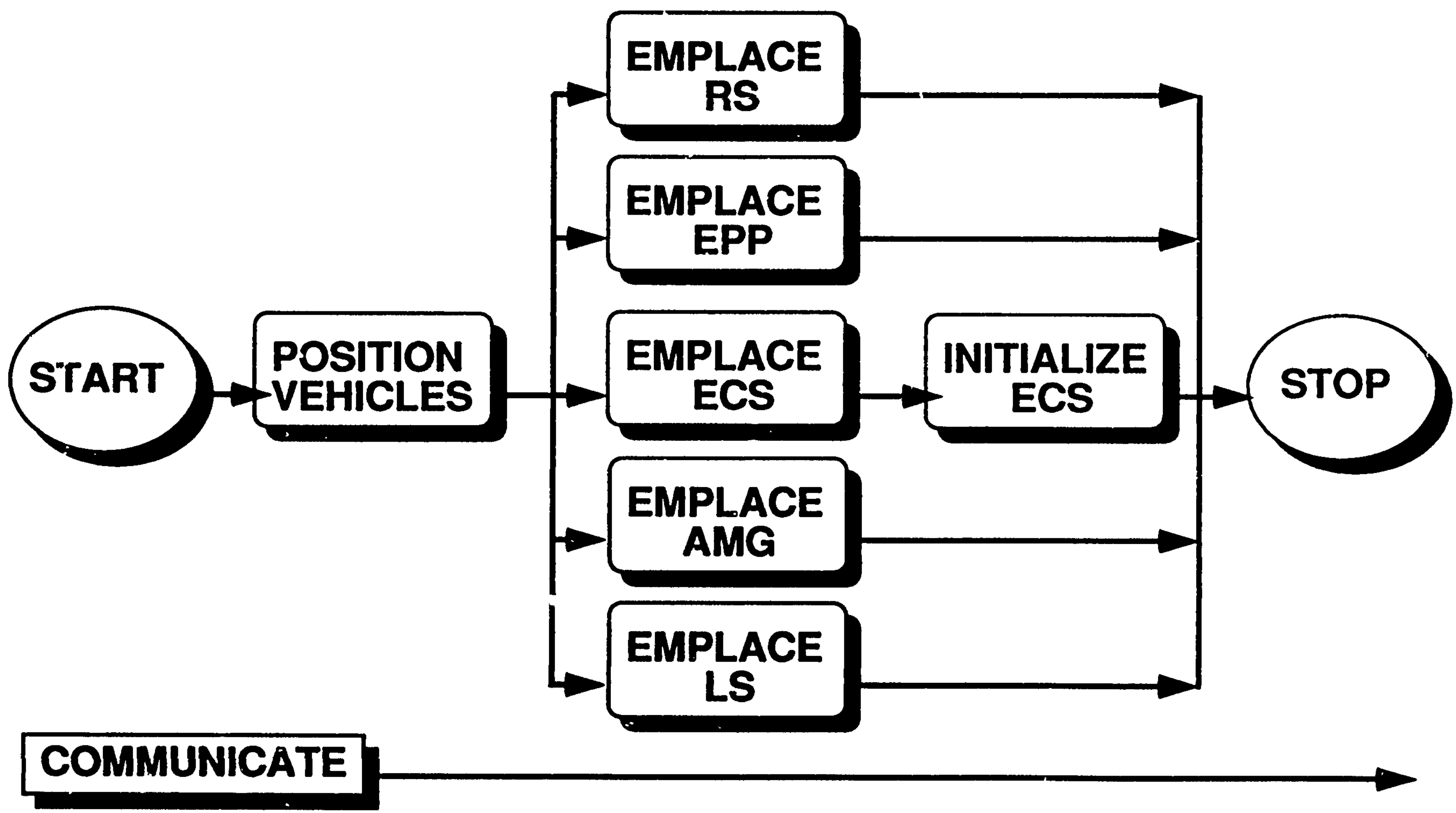
When a Patriot unit clears a release point, personnel from a reconnaissance party lead each item of equipment to the sites selected for them. Emplacement functions (e.g., position vehicles and emplace RS) for the major equipment items are represented in the network diagram. Speed is critical and teamwork is the key to minimizing overall emplacement time. The equipment items are emplaced simultaneously by different emplacement crews. Communication is represented as a continuous, cyclical function.

Each function is decomposed into subfunctions (e.g., chocking wheels, extending platforms, and performing BITE tests). Each subfunction is defined in terms of performance standards (time and accuracy criteria) and performance estimates (e.g., mean, standard deviation for performance time). The relationships among these subfunctions are also defined by networks (not shown here).

NOTE: Equipment item abbreviations are as follows,

RS = radar set
EPP = electric power plant
ECS = engagement control station
AMG = antenna mast group
LS = launching stations

PATRIOT EMPLACEMENT MODEL



SPARC APPLICATION

According to the Navigation Emplacement System (NAVES) Test and Evaluation Master Plan (TEMP), employment of NAVES should permit emplacement of the radar set (RS) and the launcher stations (LS) in adverse conditions (degraded/nighttime/non-line-of-sight) within a 12.5 minute time frame. SPARC was employed to see if this is a realistic performance criterion.

Working from data and flow diagrams resident in the data library for HARDMAN III Patriot, subject matter experts (SMEs) modified the emplacement mission to reflect the employment of NAVES. Primarily, NAVES will automate certain subfunctions (e.g., determining attitude and azimuth) and supplant certain tools (e.g., aiming circle). These subfunctions were deleted from the Patriot model for the radar set and launcher station and replaced by the subfunction of employing NAVES.

Although degraded mission conditions could be modelled in SPARC by altering the performance estimates, it was decided to simulate daytime missions. SMEs determined that daytime emplacement time criteria should be about 20% faster than the degraded conditions. Thus emplacement time criteria for the radar set (RS) and launcher sections (LS) was set at 10 minutes each. Total emplacement time for all the Patriot end items should not be greater than 32 minutes. SMEs suggested that NAVES be operable within one minute with an accuracy of 90%.

These criteria were tested by running 30 daytime emplacement missions for Patriot with NAVES. For comparison purposes, 30 missions were executed for Patriot without NAVES (i.e., baseline configuration).

SPARC APPLICATION

According to the Navigation Emplacement System (NAVES) Test and Evaluation Master Plan (TEMP), employment of NAVES should permit emplacement of the radar set (RS) and the launcher section (LS) in adverse conditions (degraded/nighttime/non-line-of-sight) within a 12.5 minute time frame.

SPARC was employed to see if this is a realistic performance criterion. Working from data and flow diagrams resident in the data library for HARDMAN III Patriot, subject matter experts modified the emplacement mission to reflect the employment of NAVES.

Criteria Tested:

NAVES - operated ≤ 1 minute with an accuracy of 90%.*
RS & LS - adverse conditions emplacement ≤ 12.5 minutes.
- daytime conditions emplacement ≤ 10.0 minutes.*

Patriot System - total emplacement time ≤ 32 minutes.*

* estimates provided by SMEs.

Simulations: 30 daytime emplacement missions of Patriot baseline and Patriot with NAVES were executed.

SPARC:
RESULTS OF DAYTIME EMPLACEMENT MISSION SIMULATIONS

Overall time criterion for emplacement of the entire Patriot firing battery ($\leq$ 32 minutes) was met by the Patriot with NAVES configuration. Employment of NAVES reduced the emplacement time for the radar set (RS) and launcher station (LS) by an average of 6 minutes and 3 minutes, respectively. However, the Patriot battery exceeded the maximum time criteria specified for the RS and LS for daytime missions ($\leq$ 10 minutes). It did not even meet the slower time criteria for adverse conditions ($\leq$ 12.5 minutes).

It appears as if the emplacement time criteria for the RS and LS, as specified in the TEMP, may be unrealistic. Even with NAVES replacing several subfunctions and estimated to operate in less than one minute, the time criteria were exceeded in the simulations. The emplacement mission should be re-evaluated to see if there is a need to adjust the Patriot with NAVES time criteria or emplacement model.

SPARC
Results of Daytime Emplacement Mission Simulation

	Overall	RS	LS
PERFORMANCE			
Baseline	27 (30)	23 (25)	16 (18)
with NAVES	25 (29)	17 (18)	13 (14)
CRITERIA			
Day	32	10	10
Adverse		12.5	12.5

Note: Mean performance times (in minutes) are presented, with maximum time values in parentheses.

CONCLUSION: Patriot with NAVES performance criteria and emplacement model should be re-evaluated for possible modifications.

MANPOWER CONSTRAINTS AID (M-CON) AND PERSONNEL CONSTRAINTS AID (P-CON)

M-CON and P-CON do not give the analyst the manpower and personnel requirements for a system, but rather provide projected manpower and personnel characteristics which should be utilized to constrain (or optimize) the design of the system. This is important because the Army cannot afford to build new systems and later discover that there are not enough people with the proper qualifications to operate and maintain them successfully.

Both M-CON and P-CON are based on a personnel flow model which is a PC version of the Manpower Long Range Planning Model used on a mainframe computer at HQ DA. This flow model uses historical transition (e.g., separation, promotion) rates to project subpopulations (e.g., based on ASVAB or gender) within the MOS on an annual basis for up to 20 years.

MANPOWER CONSTRAINTS AID (M-CON)

PERSONNEL CONSTRAINTS AID (P-CON)

START YEAR -> PROJECT INTO FIELDING YEARS -> MANPOWER & PERSONNEL CHARACTERISTICS BY MOS

PROJECTION FLOW MODEL

- INITIAL INVENTORY
- AVAILABLE ACCESSIONS
- HISTORICAL ACCESSIONS
- ADDITIONAL MIGRATIONS
- MIGRATION-IN RATES
- MIGRATION-OUT RATES
- PROMOTION RATES
- SEPARATION RATES

MANPOWER CONSTRAINTS AID (M-CON)

M-CON estimates the maximum manpower that is likely to be available to support a new system when it is fielded. Analysts can use M-CON to set manpower constraints and compare these constraints with system requirements. Used early in the acquisition cycle, manpower constraint information can influence system design.

To exercise M-CON, the user identifies the number and specific MOSs assigned to each system, specifies the number of systems and fielding years, and then runs the projection model. The model projects the manpower in the fielding year(s) based on MOS transition rates. The projection model attempts to keep the MOS profiles the same as it is currently. For example if there are 10% in the lowest mental category (i.e., CAT IV) in the MOS now, the model does not allow more than 10% CAT IVs in the future.

Knowledgeable manpower analysts can exercise a number of options available in M-CON to make adjustments to the projection model. These include adjustments for competing manpower requirements of other new systems to be fielded, for differences in MARC requirements vs. authorized spaces, for operating vs. authorization strengths, and for crew ratios. Phase-in and phase-out schedules can also be developed.

MANPOWER CONSTRAINTS AID
(M-CON)

CONCEPT:

To project the manpower likely to be available in fielding year(s) based on MOS transition rates. The model attempts to keep the MOS profile the same as it is currently (e.g. if there are 10% CAT IVs in the MOS now, the flow model does not allow more than 10% CAT IVs in the future).

METHOD:

- Identify specific MOSs and the number assigned to each system.
- Identify the number of systems and fielding years.
- Run the projection model.

OPTIONS:

- Phase-out and phase-in schedules.
- Manpower adjustments (e.g. differences in MARC requirements versus authorized spaces).

M-CON:
CURRENT PATRIOT MANPOWER STATUS

Three MOSs were examined for the Patriot emplacement mission: Patriot Missile Crewmember (16T), Patriot Operator and System Mechanic (24T), and Multichannel Communications Systems Operator (31M). For the current year (1990), the operating strength for Patriot specific MOSs (16T and 24T) fell somewhat below the authorized number. Operating strength for 31M was somewhat over the authorized number. Note that the number of 31Ms represents the total pool, and this number is high, as this MOS supports systems other than the Patriot.

M-CON
CURRENT PATRIOT MANPOWER STATUS

MOS	Authorized	Operating	ASVAB Composite	Cutoff Score
16T	1476	1295	OF	100
24T	825	786	MM	105
31M	6455	6618	EL	95

M-CON:
PATRIOT MANPOWER CONSTRAINTS FOR YEAR 1996

According to the Test and Evaluation Master Plan, no additional manpower nor new MOS should be required for operation of NAVES. Therefore, the numbers and specific MOSs which currently emplace the Patriot fire unit were assumed to remain the same with employment of NAVES. The last fielding year for NAVES is planned for 1996. There are no plans for changes in force structure, which would remain at 10 battalions composed of 6 batteries with a Patriot firing unit for each battery (i.e., 60 systems total). Current manpower requirements for emplacement of the Patriot system are twenty-seven 16T, four 24T, and three 31M. From these "per system" requirements is calculated the number of operators needed for all 60 systems.

The M-CON projection model was exercised to see if these manpower requirements are likely to be met in the fielding years. The flow model was projected through to the last fielding year of NAVES (i.e., 1996) for the three MOSs. M-CON produced the manpower constraint for each MOS (i.e., predicted the number of personnel available in the year 1996 while maintaining approximately the same personnel characteristic distribution as in 1990).

It appears that there will be a tremendous shortage of 16T by the year 1996, if personnel skill requirements are kept at current distributions. Headquarters Department of the Army Decision Science Support MOS Level System (HQ DA DSS MOSLS) showed a very low accession rate for 16T.

M-CON
PATRIOT MANPOWER CONSTRAINTS: 1996

MOS	Operators Needed Per System	Operators Needed Total	Manpower Available	Difference
16T	27	1620	396*	(1224)
24T	4	240	261	21
31M	3	180	139	(41)

* HQ DA DSS MOSLS showed very low accession rate for 16T

ASSUMPTIONS:

- NAVES will require no additional manpower; no new MOSs.
- Last fielding year is 1996.
- 60 systems - (6 batteries per bn; 10 bns).

PERSONNEL CONSTRAINTS AID (P-CON)

The P-CON Aid estimates the future distribution of key personnel characteristics. These distributions describe the number and percentage of personnel that will be available in the fielding year(s) at each level of the personnel characteristics.

To exercise P-CON, the user identifies the MOSs that are most likely to operate and maintain the system and the year(s) that the system will be fielded. Then the flow model is run to project future personnel distributions based on historical trend data. In P-CON, the flow model will try to fill the MOS with the most qualified people first, and then, in order to meet the target number, adds less qualified personnel. Often, due to the projected shortfall of manpower in the future, this will result in the MOS having personnel with lower ability levels in the fielding years.

Having information on the types of personnel who will likely be available when the system is fielded is important, but begs the question: Will these personnel be able to operate and maintain the system to a satisfactory performance standard? P-CON can address this issue by relating personnel characteristics to manned system performance. It does this by utilizing algorithms based on empirical performance data obtained from over 5000 soldiers during an ARI-sponsored research program.

P-CON produces a Personnel Characteristics Distribution Report for each MOS by year for characteristics such as ASVAB composite, AFQT, reading grade level, and education. P-CON can also produce a Target Audience Description (TAD) for any selected MOS in a format that is in accordance with Army standards. The P-CON TAD is an improvement over the one typically available since it includes personnel descriptions for each MOS, not only for the current year, but also for each year through the last fielding year.

PERSONNEL CONSTRAINTS AID
(P-CON)

CONCEPT:

To project the future distribution of key personnel characteristics through fielding year(s). P-CON tries to fill the MOS with the most qualified people first, and then, in order to meet the target number, adds less qualified personnel. P-CON can relate personnel characteristics to performance.

METHOD:

- Identify specific MOSs.
- Project through fielding year(s).
- Review future distribution.
- Examine the relationship between characteristics and performance.

OPTION:

- Target Audience Descriptions (TAD) may be printed out.

P-CON:
MOS COMPARISON REPORT

One of the reports that P-CON generates is the MOS Comparison Report. This report depicts personnel characteristics for each selected MOS for any year up through the last projected fielding year. This report can be "cut" in many different ways. For example, one can examine the personnel characteristic distribution for females or for high school graduates only. This information could be useful in selecting which MOS(s) to assign to a new system.

The report shown here is the distribution of characteristics for Patriot personnel likely to be available in the last fielding year of NAVES. This information can be incorporated into the development of requirements documents and influence the design of NAVES, as well as other system related products. For example, technical manuals could be geared towards the projected, rather than the current, reading grade level of personnel.

P-CON MOS COMPARISON REPORT
For Year 1996 (values in percentages)

	AFQT					SEX		EDUCATION	
	I	II	IIIA	IIIB	IV	MALE	FEMALE	HSG	NON-HSG
16T	4.8	36.8	26.0	25.1	7.3	82.9	17.1	95.9	4.1
24T	6.9	40.6	30.9	19.6	1.9	95.6	4.4	91.5	8.5
31M	4.1	40.2	31.9	23.1	0.7	92.2	7.8	79.6	20.4

	ASVAB						
	≤ 75	≤ 85	≤ 95	≤ 105	≤ 115	≤ 125	≤ 135
16T	0.2	4.6	16.5	27.7	30.9	17.4	2.5
24T	0.5	2.6	11.6	23.1	31.4	25.0	5.8
31M	0.4	4.2	15.0	31.5	29.9	15.4	3.7

	PULHES (EYES)			WEIGHT LIFT (MEPSCAT)		
	1	2	≥ 2	LIGHT	MEDIUM	HEAVY
16T	75.3	24.2	0.0	4.3	26.4	69.3
24T	75.8	24.2	0.0	1.1	19.4	79.4
31M	75.3	24.7	0.0	1.9	23.2	74.8

	READING GRADE LEVEL				
	≤ 7	7 - 9	9 - 11	11 - 12	≥ 12
16T	1.2	24.6	20.2	47.9	6.2
24T	0.3	17.4	19.9	54.3	8.0
31M	0.1	17.8	21.0	55.1	6.0

P-CON:
PERSONNEL CHARACTERISTICS AND PERFORMANCE

M-CON showed that there is likely to be a shortfall of 16T by the fielding year(s) of NAVES. One possible solution to the shortfall is to lower the ASVAB cutoff score for this MOS. Suppose that NAVES was not fielded and ASVAB scores had to be lowered for 16T, how would a lower ability level affect performance on those tasks that NAVES is designed to replace through automation? P-CON can be employed to address this question.

Tasks which are designated to be replaced by NAVES were selected for examination. Two of these tasks are shown here. Three ASVAB cutoff scores were chosen; the normal cutoff (100), below the normal cutoff (80), and a score above the normal (125). For Task A, lowering the ASVAB score is likely to result in decreased task accuracy with no appreciable change in time to perform the task. For Task B, lowering personnel quality may result in decreases in task accuracy as well as increases in time to perform the task.

Predicting these types of results may initially seem self-evident (e.g., lowering personnel quality produces degraded task performance). However, P-CON provides the capability to quantify that degradation and determine whether these amounts are acceptable in terms of task and system performance. For example, predicted performance degradations for those tasks which will be replaced by NAVES may provide further justification for the development of NAVES.

P-CON
PERSONNEL CHARACTERISTICS & PERFORMANCE

For two tasks to be replaced by NAVES
Performed by 16T for Year 1996

TASK	ASVAB Cutoff	TIME (minutes)	ACCURACY (% steps correct)
A			
	80	0.40	84.3
	100	0.40	86.3
	125	0.40	88.9
B			
	80	0.91	83.8
	100	0.89	85.5
	125	0.85	87.7

Note: Task A - Align aiming circle with LS position stake.
Task B - Determine LS attitude using gunner's quadrant.

MANPOWER-BASED SYSTEM EVALUATION AID (MAN-SEVAL)

MAN-SEVAL is an aid for determining whether a system design is likely to meet system performance requirements with the manpower that will be available to operate and maintain the system once it is fielded. MAN-SEVAL consists of two methods, the Maintenance Manpower Analysis Aid (MAMA) and the Workload Analysis Aid (WAA). MAMA estimates the number of maintainers needed to achieve system availability requirements. WAA evaluates whether operators can perform the required tasks in the allotted time and still maintain a reasonable level of workload. WAA also provides assistance for task reallocation, if necessary.

WAA is a tool designed to aid in the determination of the numbers of personnel needed to operate a system within desired time requirements, while avoiding workload peaks which may be detrimental to performance. Use of WAA requires an operations model decomposed into a task network with time estimates. If there is a model already set up in SPARC, it can be imported into WAA. The model can be modified to reflect a specific design concept. The user identifies likely crew positions, assigns tasks to each position, and estimates workload for each task. WAA provides benchmark scales to assist in the workload value estimation. A mission simulation can then be executed.

MANPOWER-BASED SYSTEM EVALUATION AID
(MAN-SEVAL)

CONCEPT:

Through mission simulation, to assist in the evaluation of whether a design is likely to meet the system performance requirements with the maintenance and operator crew sizes that will be available to man the system once it is fielded.

A. Maintenance Manpower Analysis Aid - estimates the number of maintainers needed to achieve system availability requirements.

B. Workload Analysis Aid - evaluates whether operators can perform the tasks in the allotted time and still maintain a reasonable level of workload. Assists in task reallocation.

WORKLOAD ANALYSIS METHOD:

- Modify function and task list to reflect system design.
- Identify crew positions.
- Assign tasks to positions.
- Estimate workload for each task.
- Execute mission simulation.

CREW WORKLOAD SUMMARY
FOR THE RADAR SET AND LAUNCHER STATION

The Workload Analysis Aid (WAA) was utilized for the Patriot Growth Application with NAVES. Crew positions and task assignments were input into WAA based on information gathered from Patriot SMEs and supporting documentation. Operation of NAVES was assigned to those crew members who would normally perform the emplacement tasks eliminated by NAVES (i.e., Radar Set Crew Member 3 (RS3) and Launcher Section Crew Member 1 (LS1), both 16T). Workload values for emplacement tasks for all RS and LS crew members were selected by an ARI research psychologist. A NAVES emplacement mission simulation was run and the results of the workload analysis are summarized below.

With NAVES design unknown at this time, it is difficult to ascertain the workload associated with operation of NAVES. However, if NAVES is designed as Patriot SMEs suggest (e.g., an easy "button pushing" operation), then there should be no need for new MOSs. Note that the percent of time in overload does not necessarily indicate that tasks are not being performed properly, but that certain tasks at certain times present periods of increased demand for the operator. An examination of the task timelines (not presented here) for crew members RS3 and LS1 show no potential workload problems for the employment of NAVES. That result was not unexpected, as NAVES replaces tasks which were performed by these crew members and does not impose an additional burden.

CREW WORKLOAD SUMMARY
RADAR SET AND LAUNCHER SECTION

Crew Member Position	Number of Tasks Assigned	Percent of Time in Overload
Radar Set		
RS1 (24T)	16	0.7
RS2 (24T)	60	10.1
RS3 (16T)	3	0
RS4 (16T)	12	0.3
Launcher Section		
LS1 (16T)	25	2.3
LS2 (16T)	18	11.2

Note: NAVES operation was assigned to crew members RS3 and LS1.

PERSONNEL-BASED SYSTEM EVALUATION AID (PER-SEVAL)

The purpose of PER-SEVAL is to find the level of personnel characteristics needed to meet system performance requirements, given a particular hardware design. PER-SEVAL accomplishes this by predicting task performance as a function of key personnel characteristics and frequency of training, degrades these performance estimates to reflect critical environmental stressors, and estimates manned system performance through mission simulation. PER-SEVAL allows users to perform trade-off analyses to resolve performance discrepancies. They can adjust training frequency, environmental conditions, and personnel characteristics to attain desired performance levels.

PER-SEVAL analysis is based on the system design, crew assignments, and workload values described in MAN-SEVAL. The PER-SEVAL user specifies various factors to be taken into account in the mission simulation. These factors include personnel characteristics (ASVAB or AFQT scores), training frequency, and environmental stressors (heat, cold, noise, continuous operations, MOPP level). PER-SEVAL uses equations derived from the Ballistics Research Laboratory's AURA Model and the ARI Project A Database to derive performance estimates through mission simulation. In essence, PER-SEVAL brings the relationship between human differences and system performance to the evaluation of individual systems.

PERSONNEL-BASED SYSTEM EVALUATION AID
(PER-SEVAL)

CONCEPT:

To estimate how various factors (personnel characteristics, training frequency, environmental stressors) affect individual task and overall mission performance. It can also assess the impact of maintenance task performance on availability and maintainability measures.

METHOD:

- Analysis is based on system design, crew assignments and workload demands described in MAN-SEVAL.
- Specify various factors:
  - Personnel characteristics (mental category and ASVAB composite cutoff.
  - Training frequency.
  - Environmental stressors (heat, cold, noise, continuous operations, MOPP level).
- Simulate missions.

PL '-SEVAL:
PATRIOT WITH NAVES EMPLACEMENT MISSION SIMULATIONS

The Patriot with NAVES emplacement model was imported from MAN-SEVAL into PER-SEVAL. Two different mission types were specified and executed for three runs each. Mission Type A was run as a "baseline" case, with normal ASVAB cutoffs for personnel, standard training, and no environmental stressors applied. Mission Type B was set up to simulate a future "worst case" scenario. For Mission B, personnel quality was lowered (i.e., lower ASVAB cutoff scores) in anticipation of a manpower shortage, and training frequency was not increased. Environmental stressors were applied in the form of continuous operations in MOPP Level 4.

Simulation results for the baseline case (Mission Type A) indicated successful emplacement (i.e., meeting time and accuracy criteria specified in SPARC) for all three missions. For the worst case scenario (Mission Type B), simulations predicted two mission aborts due to failures to meet time and accuracy criteria for successful emplacement. The time it takes tc emplace the Patriot system may increase up to 40% under these degraded conditions.

PER-SEVAL
PATRIOT WITH NAVES EMPLACEMENT
MISSION SIMULATIONS

Mission Type	Mission Time (minutes)	Number of Mission Aborts (out of 3 missions)	Failures due to Time	Failures due to Accuracy
A	24.5	0	0	0
B	34.6	2	1	1

Mission Type:

A - Personnel (16T ASVAB cutoff 100, 24T cutoff 105)
Standard training, no environmental stressors

B - Personnel (16T ASVAB cutoff 85, 24T cutoff 95)
Standard training
Environmental stressors:
Temperature: 25 - 34 degrees (centigrade)
Humidity: 11 - 20 percent
MOPP: Level 4
Continuous operations: 25 - 47 hours since last slept

HARDMAN III ANALYSES
SUMMARY

Analyses were conducted by DCD and ARI to demonstrate the capabilities of HARDMAN III on a proposed materiel change for the Patriot Growth program.

SPARC evaluated, through mission simulation, the emplacement time criteria for the Patriot system when equipped with NAVES. It was found that even though employment of NAVES reduces the emplacement time for the Radar Set (RS) and Launcher Station (LS), the manned system does not meet the time criteria specified in the Test and Evaluation Master Plan (TEMP). This could result in time and dollars spent building and testing a system which may not have the capacity to meet its performance criteria. Patriot with NAVES performance criteria and emplacement model should be re-evaluated for possible modifications.

Using M-CON to project into the fielding years of NAVES, it was found that there may be a shortfall of 16T if personnel ability requirements are not lowered (e.g., lowering ASVAB cutoff scores). If personnel requirements were lowered for 16T, to make up for the manpower shortage, there will be a degradation in task time and accuracy. The degree of degradation was demonstrated by P-CON on radar and launcher emplacement tasks which will be replaced by NAVES. Development of NAVES is further justified by the projected manpower and personnel constraints.

The TEMP also states that NAVES will not result in the addition of vehicles, personnel or new military occupational specialties. The Workload Analysis Aid (WAA) in MAN-SEVAL confirmed that the projected crew workload requires no additional personnel or new MOSs.

PER-SEVAL examined the effects on emplacement task performance with lower personnel ability levels (in anticipation of a manpower shortage) in a scenario with environmental stressors (continuous operations in MOPP Level 4). PER-SEVAL simulation demonstrated that under these conditions, Patriot Fire Battery emplacement time may increase up to 40% and may fail to meet task accuracy requirements.

HARDMAN III ANALYSES

SUMMARY:

SPARC: Re-evaluate NAVES performance criteria and emplacement model.

M-CON: Possible shortage of 16T in fielding years if personnel ability requirements are not lowered.

P-CON: Decreased performance accuracy for radar and launcher orientation and emplacement tasks by 16T (with lowered ASVAB cutoffs) in projected years provides additional justification for NAVES.

MAN-SEVAL: Employment of NAVES is not likely to require additional crew members or new MOSs.

PER-SEVAL: If ASVAB cutoff scores are lowered and emplacement is performed with environmental stressors, Patriot Fire Battery emplacement time may increase up to 40% and may fail to meet task accuracy requirements.

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